Survey-based Stock Trends for Puget Sound Groundfishes: Monitoring the Road to Recovery

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Abstract

Many species of groundfishes in Puget Sound have shown dramatic declines in fishing success. These indices have been used a proxies for long-term population trends, and have, in part, led to an Endangered Species Act petition for six groundfishes. Management measures have been instituted to curtail directed fishing at depressed populations, but once these tools are implemented, the proxy measures are affected in unknown manners. Since 1987, the Washington State Department of Fish and Wildlife has undertaken direct population surveys to estimate population abundance of key groundfish species. The survey methods include the use of trawls, scientific echosounders, a quantitative video sampler, and scuba transects. These methods and survey schemes are described and their estimates are compared to fishery-based indices. Although the surveys do not extend to the early periods of high fishing success, many of the trends agree with the measures of fishing success. The direct population surveys also provide tools to continue assessing population trends where fishing has been discontinued and to evaluate the success of conservation measures enacted to rebuild depressed groundfish populations.

Introduction

Comprehensive stock assessments of groundfishes in Puget Sound have been primarily conducted using information derived from commercial and recreational fisheries (Palsson and others 1997; PSAT, 2000). These assessments have found that the majority of groundfish populations in Puget Sound are in poor condition. Some of the data from these assessments have led to a petition of 18 species of groundfish to be considered under the terms of the Endangered Species Act (Wright 1999). Regardless of the outcome of this petition, serious declines of several groundfish populations assessed using fishery-based methods have resulted in fishery closures and population rebuilding programs. The success of these management efforts will depend upon reliable measures of stock abundance that are not dependent upon open fisheries (Palsson and others 1998).

The primary stock assessment technique to monitor groundfish populations in Puget Sound has been to compare annual catch per unit effort trends in relation to short (2 or 5 year) and long-term (20 year) time frames (Palsson and others 1997). Catch rate trends can be used as a relative measure of stock abundance if the chance of catching a fish does not change during the assessment period (Hilborn and Walters 1992). Often the catchability assumption is not valid because of technological improvements to fishing, fish behavior results in non-random distributions, especially by fish aggregations, or market conditions and regulations that affect fishery performance.

Preferred stock assessments are conducted by estimating catch at age and applying population estimates of natural and fishing mortality, recruitment, growth, and maturity to models that reconstruct past population sizes and project them into the future. Surveys using trawls, scuba, video and other devices are designed to estimate population abundance and are valid assessment techniques that are independent of fishery data In Puget Sound, the ability to model populations quantitatively is not possible because a lack of resources prevents catch-at-age estimation and the determination of key population parameters. A number of efforts have been undertaken beginning in the mid-1980s to directly survey populations on a comprehensive basis or at index sites (Matthews 1990; Quinnell and Scmitt 1991; Palsson and others 1997). The surveys provide a basis to compare fishery independent measures of stock abundance with catch per unit trends during the same period. The purpose of this paper is to examine a subset of survey and fishery dependent trends and evaluate the consistency between the two measures of population abundance.

Methods

Population data were collected from bottom trawl surveys, and catch per unit effort analyses were conducted for English sole (*Pleuronectes vetulus*), starry flounder (*Platichthys stellatus*), Dover sole (*Microstomus pacificus*), Pacific cod (*Gadus macrocephalus*), spiny dogfish (*Squalus acanthias*), skates (*Raja* spp.) and spotted ratfish (*Hydrolagus collei*). Dive survey and fishery data were also compiled for three rockfishes: copper rockfish (*Sebastes caurinus*), quillback rockfish (*S. maliger*), and brown rockfish (*S. auriculatus*). Catch rates from commercial and fishery data were compiled on an annual basis and were expressed in terms of catch per landing for commercial set line and set net fisheries, catch per hour for the bottom trawl fishery, and as catch per bottomfish trip for the boat-based recreational fishery (Palsson and others 1997).

Bottom trawl surveys have been conducted in Puget Sound beginning in 1987 when all waters were surveyed except the San Juan Islands (Quinnell and Schmitt 1991). This sound-wide trawl survey was repeated in 1989 and 1991 (Palsson and others 1997). Beginning in 1994, the surveys focused on one or two regions per year and were conducted in the U.S. Strait of Georgia and adjacent bays in 1994 and 1997. Central Puget Sound was surveyed in 1995, and South Puget Sound and Hood Canal were surveyed in 1996. The eastern Strait of Juan de Fuca was surveyed in 2000. A stratified-systematic survey design was used to locate stations within four depth zones: 5 fathoms to 20 fathoms, 21 fathoms to 40 fathoms, 41 fathoms to 60 fathoms and greater than 60 fathoms. A chartered vessel was used to tow a large commercial bottom trawl fitted with a 3.2 cm mesh liner. The net was typically towed for 10 minutes, and the distance fished determined with navigation equipment. Net widths were determined by a special study and were found to range from 9 m to 14 m depending upon the depth and amount of wire let out from the boat. All fish were enumerated and weighed and some were measured. The density of fish from each trawl sample was determined by dividing the weight of each species sampled by the area swept determined from the product of the distance fished and net width.

Dive surveys were conducted in central Puget Sound at four index sites during 1986 and 1987 by Matthews (1990), and later, the same sites and transect lines were surveyed from 1995 to 1997. These sites included the artificial reefs at Blake Island and Boeing Creek and the natural rocky habitats at Orchard Rocks and Port Blakely. At each of these sites three 30-meter lines were permanently installed along the 14 m isobath or in a manner to encompass the significant portions of the habitat and to match the mix of rocky habitat features such as complexity and relief. Survey methods were those used by Matthews (1990) and modified by Palsson and Pacunski (1995). One or two divers surveyed all the rockfish within 1.5 m of either side of each transect line. Sampling occurred in the 1990s during from April to June and from September to December. The data from these months were compared to those data from the same months collected in the 1980s.

For the analysis, fishery and trawl survey observations were combined into a North Sound area and a South Sound area. The main analytical approach was to determine the trend of the fishery catch per unit effort data in a qualitative manner and compare the fishery trend to the statistical trend of the density estimates from the trawl surveys. Because less than five bottom trawl survey estimates exist, regression or correlation statistical techniques were not attempted. Instead, a simple determination of trend in the catch per unit effort data was made by inspecting the catch rates of the last three years fishery data and determining whether the values were higher, lower, or similar to the catch rates of the previous years. These catch rate trends were compared with the results from analysis of variance tests conducted for each species using the individual trawl density observations in a one-way test for differences among years. If densities differed among years, Tukey Multiple Range Comparisons were conducted to determine which years differed from each other. Because many species occurrences differed among depth strata, only the strata with greater and significantly different densities resulting from an analysis of variance test for density differences among depth strata were used. The among-year trend in trawl survey density estimates was determined by comparing any significant difference the last survey density estimate with the higher or lower magnitudes of the previous year′s estimates. The second analysis consisted of comparing long-term catch rate trends of rockfish South Puget Sound with the results of an analysis of variance of fish densities from the four central Puget Sound among years. Trend comparison of the dive observations and fishery trend occurred in a similar manner to the fishery and trawl survey estimates.

Results

The species chosen for comparison showed a great range of either increasing, decreasing, or no trend in the catch per unit effort obtained from commercial or recreational fisheries (Table 1). Only North Sound rock sole and South Sound dogfish did not exhibit a clear fishery trend. In eight cases, there were no fishery data to determine a trend either because of the closure of South Sound to bottom trawling in 1989 or because ratfish are not retained by commercial fishers in North Sound. In 11 of the 19 possible combinations, the survey density observations did not demonstrate any recent increasing or decreasing trend (Table 1).

Overall, there was poor correspondence between the trend of the fishery catch rates and the trend in the trawl densities (Table 1). In only three of the ten cases when fishery and trawl survey density data were available did the pattern in the catch rates and densities agree. In two of the three comparisons both the trends were negative and in the third circumstance the indicators both showed no trend. For six of the seven cases where the two indicators disagreed, the trawl survey densities showed no recent trend while the fishery data indicated an increase in four comparisons and a decline in one case. In one other comparison, the fishery exhibited no trend while the survey densities indicated a declining trend. In only one case did one indicator exhibit an increasing trend while the other exhibited a declining trend.

Table 1. Fishery and Survey Trend Comparisons

	North Sound		**South Sound**	
Species	**Fishery**	**Survey Densities**	**Fishery**	**Survey Densities**
Spiny dogfish	Decline	Decline	None	Decline
Skates	Increase	Slight decline	Unknown	Decline
Spotted Ratfish	Unknown	None	Unknown	None
Pacific cod	Decline	None	Decline	Decline
English sole	Increase	None	Unknown	Decline
Large English sole	Increase	None	Unknown	Decline
Rock sole	None	None	Unknown	None
Starry flounder	Increase	None	Unknown	None
Dover sole	Increase	None	Unknown	Decline
Rockfish			Decline	Decline

The dive data primarily demonstrated a sharp decrease in the densities of copper and quillback rockfishes at the four sites monitored in central Puget Sound between the 1980s and the 1990s (Figures 1 and 2). These declines corresponded to a declining trend in the recreational catch rate during the same monitoring period (Figure 3). Brown rockfish densities, however, showed a significant increase during the two study periods (Figure 4).

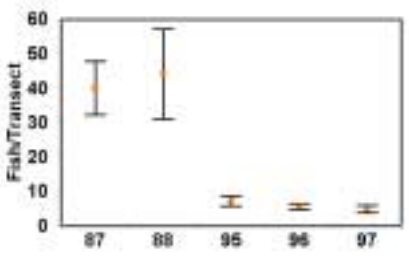

Figure 1. Density of copper rockfish in 270 sq. m dive transects averaged among four central Puget Sound sites.

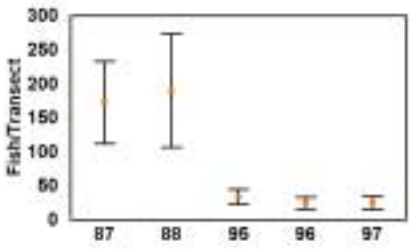

Figure 2. Density of quillback rockfish in 270 sq. m dive transects averaged among four central Puget Sound sites.

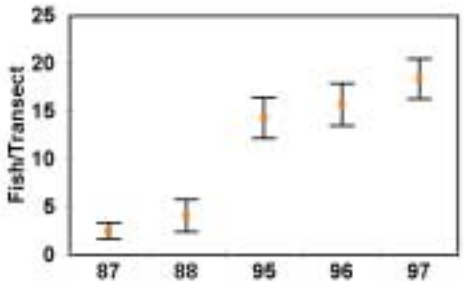

Figure 4. Density of brown rockfish in 270 sq. m dive transects averaged among four central Puget Sound sites.

Figure 3. Rockfish catch (numbers) per bottomfish trip for boat-based recreational fishers in southern Puget Sound.

Discussion

This preliminary analysis of fishery and survey data demonstrated that in only a minority of cases did trends agree for comparable areas and times. The common disagreements in the fishery and trawl survey data indicate that one or both methods of characterizing population trends suffer from violations of critical assumptions or a lack of power in their design and application. In most cases of disagreement, the trawl survey data indicated there was no trend while the fishery data indicated a positive or negative trend. This pattern suggests that the trawl surveys lacked sufficient replication and power to determine a trend or that the surveys were not frequent enough to mirror the trend in the fishery. During the first three trawl surveys, the entire Sound was sampled with relatively few samples were taken in any region. Beginning in 1994, 25 to 40 trawl samples were collected in a region, but fewer regions were covered in a year and surveys were only conducted sporadically. The sporadic nature of the surveys resulted in combining data from 1997 and 2000 to characterize survey densities and only using the 1994 survey of the Strait of Georgia to characterize North Sound.

The disparity between the fishery catch rates and trawl surveys may also be explained the critical assumption that catchability for fish exploited in the fisheries does not change over time. Many factors may contribute to the violation of the constant catchability assumption including changes in targeting patterns, advances in fishing power such as improved nets, boats, and navigation equipment, and changes in fish

behavior (Hilborn and Walters 1992). In four cases in North Sound, fishing success for English sole, starry flounder, and Dover sole demonstrated increasing trends at the same time the trends for Pacific cod were decreasing. The surveys for these species showed no trend suggesting targeting and fishery management patterns may be affecting fishery catch rates. Although the trawl survey showed no trend in cod populations in North Puget Sound, long-term fishery catch rates have shown dramatic declines that the tenure of trawl surveys may not have captured.

The bottom trawl surveys did provide the means to assess stocks in South Sound where the discontinuation of the trawl fishery in 1989 precluded a fishery dependent measure of population abundance. While most trawl survey densities showed no trend in North Sound, most trawl survey densities showed a declining trend in South Sound. Despite the cessation of fishing, English sole populations appear to be continuing the decline in South Sound observed by Palsson and others (1997) prior the fishery closure in 1989. The bottom trawl survey also provided population information on spotted ratfish, the most abundant bottomfish in Puget Sound in terms of biomass. Although ratfish are often caught as bycatch in bottom trawl fisheries, they are not typically recorded as catch, so no information about population status is obtained from the fishery.

The dive survey at four index sites in Puget Sound demonstrated substantial declines in copper and quillback rockfish abundance, species that have constituted the majority of the recreational harvest in South Puget Sound. Although brown rockfish densities increased during the two decades, they have not become dominant in the recreational catch. The decline in the recreational catch rate in South Sound corresponds to the decline in the densities of the two primary recreational species suggesting that the decline in rockfish populations is real and not attributed to changes in regulations controlling daily limits of rockfish harvest during the study period.

Because many populations in Puget Sound are in serious decline, extreme measures have been taken to remove the impacts of recreational and commercial fisheries by partial or complete fishery closures or severe restrictions. The changes to catchability by these management actions compromise the use of catch rate analysis and other fishery dependent stock assessment methods. While there is great disagreement between fishery and survey measures of population abundance, surveys do show that they can detect severe population declines and with improved precision hold a key for monitoring the recovery of depressed groundfish populations in Puget Sound. It is recommended that bottom trawl, dive, and other surveys be increased in frequency, sample size and scope in order to detect finer differences in population change and cover the entire range of occurrence.

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